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BENEFICIATION OF TWO DRILL CORE SAMPLES OF KAOLINISED SAND FROM BLACK ISLAND, MANITOBA

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MICROMEDIA

BENEFICIATION OF TWO DRILL CORE SAMPLES OF KAOLINISED SAND
FROM BLACK ISLAND, MANITOBA

by

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ABSTRACT

Two samples of kaolinised sand, A and B were processed by a combination of scrubbing, washing, classification and flotation to remove the coarse silica and concentrate the kaolin. Two products of concentrated kaolin, -25 +6 μm and -6 μm , were produced from each sample.

The -6 μm fraction produced from each sample analysed approximately 28% Al_2O_3 . The brightness value for each product, at 73%, limits the use of -6 μm material to low-grade filler quality.

The intermediate -25 +6 μm fraction was successfully concentrated by flotation; concentrates analysing 36.5% Al_2O_3 for Sample B, and a concentrate analysing 31.9% Al_2O_3 for Sample A were obtained. The brightness values of the flotation concentrates for each sample, at 73%, could not be significantly increased by either magnetic separation or acid leaching. The low brightness value of this intermediate size fraction limits its use to low-grade filler quality.

The probable reason for the relatively low brightness values was the presence of iron oxide minerals; flotation concentrates contain approximately 2.00% Fe_2O_3 .

Keywords: Kaolin, processing, magnetic separation, acid leaching, brightness values.

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ENRICHISSEMENT DE DEUX ÉCHANTILLONS CAROTTÉS DE SABLE
KAOLINISÉ, PRÉLEVÉS À BLACK ISLAND, MANITOBA

par

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RÉSUMÉ

Deux échantillons de sable kaolinisé, A et B, ont été traités au moyen des procédés d'épuration, de lavage, de classification et de flottation combinés en vue d'enlever la silice grossière et de concentrer le kaolin. Deux concentrés de kaolin, de $-25 +6 \mu\text{m}$ et $-6 \mu\text{m}$, ont été obtenus à partir de chacun des échantillons.

La fraction de $-6 \mu\text{m}$, obtenue à partir de chaque échantillon, titrait approximativement 28 % Al_2O_3 . Une valeur de luminance de 73 % pour chacun des produits de $-6 \mu\text{m}$ fait que ceux-ci ne peuvent être utilisés qu'en tant que produits d'apport de qualité inférieure.

On a réussi à concentrer la fraction intermédiaire $-25 +6 \mu\text{m}$ par la flottation; des concentrés titrant 36,5 % Al_2O_3 pour l'échantillon B, et un concentré titrant 31,9 % Al_2O_3 pour l'échantillon A, ont été obtenus. Les valeurs de luminance des concentrés de flottation qui étaient de 73 % pour chacun des échantillons, n'ont pu être augmentées de façon tangible, soit par la séparation magnétique ou la lixiviation à l'acide. Les faibles valeurs de luminance de cette fraction de dimension intermédiaire font que le produit ne peut être utilisé que comme produit d'apport de qualité inférieure.

Il est probable que les faibles valeurs de luminance sont dues à la présence de minerais d'oxyde de fer; les concentrés de flottation contenaient environ 2,00 % Fe_2O_3 .

Mots clé : kaolin, traitement, séparation magnétique, lixiviation à l'acide, valeurs de luminance.

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INTRODUCTION

Earlier beneficiation of Black Island kaolin (1,2) had indicated that kaolin could be upgraded to between 34% and 36% Al_2O_3 , which would indicate filler grade quality. Brightness values were, however, relatively low at 67.3% which would imply only low-grade filler quality. A possible explanation for this low value was that the original sample was contaminated. The sample was shipped in a wet state in metal drums and the inside surfaces of some of the drums exhibited considerable corrosion attack.

It was recommended that further testwork be conducted on representative material from different parts of the deposit, and that the samples be transported in a dry state in plastic bags. This would reduce the possibility of contamination.

SAMPLE DESCRIPTION

Three drums of bagged kaolinised sand were received in the Industrial Minerals Laboratory in May 1987. Each sample was weighed and identified as follows:

Hole #4	- Sample A	12.56 kg
Hole #15	- Sample B	11.47 kg
Hole #9	- Sample C	19.60 kg

A brief examination of each sample indicated that there was no extraneous contamination.

PROCESSING

Size Reduction

Each sample was crushed to 6 mm in a laboratory jaw crusher, and to 840 μm in a laboratory roll crusher. A representative head portion from each was removed for size and chemical analysis.

Head Sample

Each head portion was wet screened at 44 μm and the oversize and undersize fractions dried, weighed and analysed for SiO_2 , Al_2O_3 , Fe_2O_3 , TiO_2 , CaO and MgO ; the results are reported in Table 1. Brightness tests were conducted on each fraction using a Photovolt 577 Reflection meter equipped with a blue filter; results are reported in Table 4. A summary of the head sample analyses is reported as follows:

Sample	% Al_2O_3
A	18.8
B	12.4
C	17.8

Scrubbing and Washing

Since the head analysis of Sample A, at 18.8% Al_2O_3 , was similar to Sample C, at 17.8 % Al_2O_3 , it was decided to process only Sample A. Sample B was processed since it represented a lower grade portion of the deposit.

Sample A was divided into two portions using a laboratory riffle; each portion weighing approximately 5 kg. Each 5 kg portion was processed separately in the laboratory Wemco attrition scrubber for 40 min at 75% solids. Attrition scrubbing is an efficient method of delaminating kaolin and freeing it from coarse silica grit.

After scrubbing, each portion was wet screened at 44 μm and the -44 μm undersize was further screened at 25 μm . The -25 μm undersize was further classified using a Mozley 25 mm hydrocyclone with a 4.8 mm spigot discharge and 4.8 mm vortex orifice, to separate a high-grade cyclone overflow kaolin fraction. The size of the cyclone overflow was determined as 6 μm using a laboratory Sedigraph. Each fraction, +44 μm , -44 +25 μm and -25 +6 μm , was dried, weighed and analysed for the principal oxides, and brightness determinations conducted. The results of the product balance are reported in Table 1.

The same procedure was used to separate kaolin in Sample B; the results of the product balance also are reported in Table 1.

Flotation

Previous testwork has demonstrated that kaolin tends to concentrate in the $-6\ \mu\text{m}$ size range, and that at sizes $>25\ \mu\text{m}$ very little kaolin is present. Kaolin in the intermediate $-25\ +6\ \mu\text{m}$ size range was best beneficiated by cationic flotation⁽²⁾. Cationic flotation was therefore used to concentrate kaolin in the $-25\ +6\ \mu\text{m}$ size range of both Sample A and B.

Two tests were conducted with each sample; Duomeen TDO collector (tallow diamine propane dioleate) at pH 2.0 in the first test, and Armac T collector (tallow amine acetate) at pH 2.0 in the second test. Stage addition of collector was necessary in each test to minimize the flotation of silica fines. The depression of silica also was aided by the addition of sodium silicate. Product balances of flotation tests are reported in Table 2 and the reagent concentration data in Table 3. Brightness test values of selected samples were conducted using a Photovolt 577 Reflection meter using the blue filter and standard magnesium carbonate methods; values are reported in Table 4.

Magnetic Separation

While flotation separates kaolin from quartz, the iron oxide minerals associated with the kaolin tend to report with the kaolin. The final flotation concentrate products from Sample A (Tests 1 & 2), which contained approximately 2.00% Fe_2O_3 were therefore combined and passed through the Jones wet high intensity magnetic separator to remove magnetic minerals. This procedure was repeated using combined flotation concentrate products from Sample B (Tests 3 & 4).

Product balances of the magnetic separation tests are reported in Table 5, and brightness values of the non-magnetic products in Table 4.

Acid Leaching

Leaching of kaolin is an established method of improving brightness, so that small portions of the non-magnetic fraction of Sample A & B were leached using 50% HCl to further reduce iron oxide content. After washing and drying brightness tests were conducted on the leached residue; results are reported in Table 4.

RESULTS

The results in Table 1 indicate that after washing and scrubbing the grade % Al_2O_3 of the -25 +6 μm size fraction of both Sample A & B are similar; the grade % Al_2O_3 of the -6 μm size fraction of both samples also are similar. The weight recoveries of the -25 +6 μm and -6 μm size fractions for Sample A are, however, higher than the weight recoveries for the same size fractions for Sample B, which is to be expected because Sample A is higher grade than Sample B. The analysis of the -6 μm fraction of each sample, at approximately 28% Al_2O_3 , is in agreement with previous size-grade relationships as demonstrated in Fig. 1. The brightness values of the -25 +6 μm fraction for both Sample A and B were similar at 69%; the -6 μm fractions gave slightly higher brightness values at 74% for Sample A and 72% for Sample B. The +25 μm size fraction for each sample contained very little kaolin and analysed approximately 90% SiO_2 .

The response to flotation of the -25 +6 μm fraction was similar to the response previously demonstrated⁽²⁾. The results obtained using Duomeen TDO collector were better with Sample B than with Sample A. A concentrate analysing 36.5 % Al_2O_3 at 51.6% recovery was obtained for Sample B, whereas for Sample A a concentrate analysing 31.9% Al_2O_3 was obtained for a recovery of 42.6%. The results obtained with Armac T collector were not as selective as with Duomeen TDO collector for both samples. The brightness values of the flotation concentrates for Sample A and B were similar at 73%.

The removal of iron oxide minerals from combined flotation concentrates for Sample A and B by magnetic separation was virtually negligible; for Sample A, 17.5% was removed and for B 10.2% was

removed. The inability to substantially reduce the iron oxide content also was demonstrated by the brightness values of the non-magnetic products, which remained unchanged at 73%.

Acid leaching partially reduced some of the iron-oxide content, but analyses of leached non-magnetic product Sample A at 2.08% Fe_2O_3 and B at 1.72% Fe_2O_3 only indicated an insignificant reduction. Furthermore, brightness values of each leached product remained unchanged at 73%.

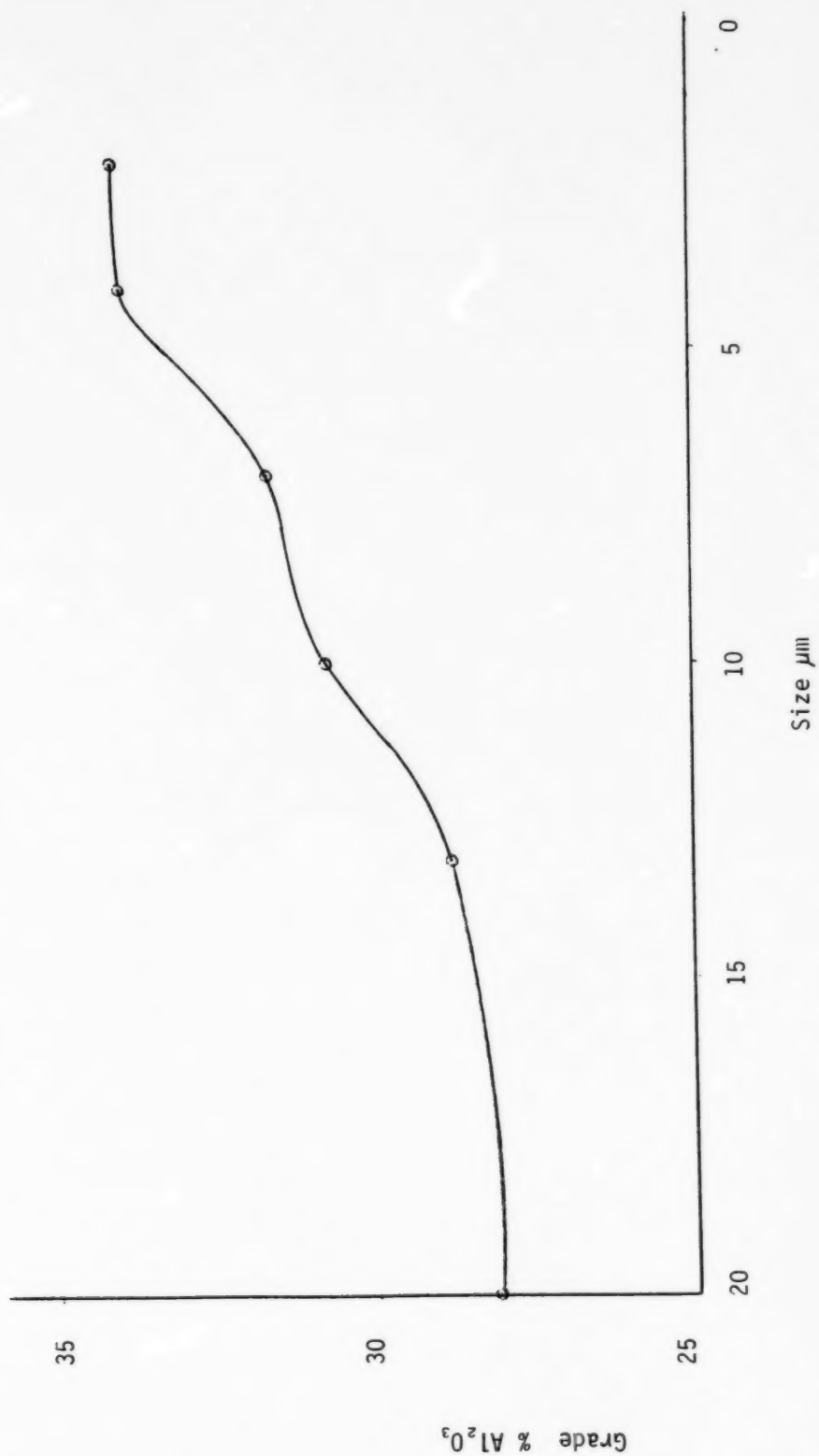


Fig. 1 Size-grade Al_2O_3 relationships in the $-4\mu\text{m}$ range

CONCLUSIONS

A $-6\ \mu\text{m}$ fraction corresponding to approximately 28% Al_2O_3 can be separated from Sample A and Sample B material. The brightness values for each product, at 73%, limits use to low-grade filler quality.

The intermediate $-25\ +6\ \mu\text{m}$ fraction was successfully concentrated by flotation. A concentrate analysing 36.5% Al_2O_3 at 51.6% relative recovery was obtained for Sample B, whereas for Sample A a concentrate analysing 31.9% Al_2O_3 was obtained for a relative recovery of 42.6%. The brightness values of the flotation concentrates for each sample, at 73%, could not be significantly increased by either magnetic separation or acid leaching. The low brightness value of this intermediate size fraction limits its use to low-grade filler quality.

The probable reason for the relatively low brightness values is the presence of iron oxide minerals; flotation concentrates contain approximately 2.00% Fe_2O_3 .

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Table 1 - Head sample analyses

Sample	Product Size μm	Wt %	Analysis %						Distribution %					
			Fe ₂ O ₃	TiO ₂	CaO	SiO ₂	Al ₂ O ₃	MgO	Fe ₂ O ₃	TiO ₂	CaO	SiO ₂	Al ₂ O ₃	MgO
A														
	+45	16.1	1.62	1.59	1.04	84.9	4.86	0.21	20.1	49.1	67.8	19.9	4.2	5.0
	-45 +25	9.2	0.38	0.29	0.11	93.4	3.44	0.07	2.7	5.2	4.1	12.5	1.7	0.9
	-25 +6	22.1	0.90	0.36	0.05	77.8	13.11	0.47	15.3	15.4	4.5	25.0	15.4	15.4
	-6	52.6	1.53	0.30	0.11	55.6	28.10	1.01	61.9	30.3	23.6	42.6	78.7	78.7
	Head (calculated)	100.0	1.30	0.52	0.25	68.7	18.78	0.68	100.0	100.0	100.0	100.0	100.0	100.0
B														
	+45	48.0	0.37	0.17	0.30	94.4	2.60	0.05	23.9	17.5	61.0	54.0	10.1	9.6
	-45 +25	5.6	0.60	0.28	0.39	89.4	5.62	0.06	4.6	3.4	9.3	6.0	2.5	1.2
	-25 +6	12.5	0.65	0.77	0.05	84.5	11.78	0.20	10.9	20.5	2.5	12.6	11.9	10.0
	-6	33.9	1.33	0.81	0.19	68.1	27.60	0.58	60.6	58.6	27.2	27.4	75.5	79.2
	Head (calculated)	100.0	0.74	0.47	0.24	84.0	12.39	0.25	100.0	100.0	100.0	100.0	100.0	100.0
C														
	+45	55.4	0.50	0.28	0.28	84.3	9.04	0.07	44.3	24.7	67.1	65.1	27.9	41.9
	-45	44.6	0.78	0.17	0.17	56.2	29.03	0.12	56.7	75.3	32.9	34.9	72.1	58.1
	Head (calculated)	100.0	0.60	0.50	0.24	71.8	17.60	0.07	100.0	100.0	100.0	100.0	100.0	100.0
	Head (measured)		0.60	0.50	0.24	71.8	17.8	0.07						

Table 2 - Flotation product balances

Sample Test	Products	Wt %	Analysis %					Distribution %				
			Fe2O3	TiO2	SiO2	Al2O3	MgO	Fe2O3	TiO2	SiO2	Al2O3	MgO
A	1 Final conc.	16.3	2.22	0.30	48.6	31.9	1.20	43.1	13.7	10.0	42.6	44.0
	2nd cleaner tails	10.1	1.53	0.59	61.5	23.8	0.83	18.5	16.8	7.8	19.7	18.5
	1st cleaner tails	36.2	0.82	0.56	78.8	12.1	0.43	35.3	56.9	35.9	35.8	34.3
	Rougher tails	37.4	0.07	0.12	98.4	0.63	0.04	3.1	12.6	46.3	1.9	3.2
	Head (calculated)	100.0	0.84	0.36	76.5	12.22	0.46	100.0	100.0	100.0	100.0	100.0
A	2 Final conc.	14.4	2.02	0.66	51.0	30.3	1.06	30.2	26.1	9.6	31.1	31.7
	2nd cleaner tails	17.6	0.72	0.35	82.9	10.0	0.34	13.3	17.0	19.2	12.6	12.4
	Rougher tails	34.7	1.49	0.52	62.2	22.0	0.77	53.7	49.5	28.3	54.6	55.3
	Head (calculated)	33.3	0.08	0.08	98.2	0.70	<0.01	2.8	7.4	42.9	1.7	0.6
B	3 Final conc.	100.0	0.96	0.36	76.2	13.99	0.48	100.0	100.0	100.0	100.0	100.0
	2nd cleaner tails	17.0	2.02	0.57	54.2	36.5	0.64	51.4	12.4	10.9	51.6	51.7
	1st cleaner tails	8.2	1.18	1.75	67.9	25.6	0.39	14.6	18.4	6.6	17.4	15.2
	Rougher tails	21.3	0.71	1.44	81.5	14.7	0.20	22.7	39.2	20.5	26.0	20.4
	Head (calculated)	53.5	0.14	0.44	97.9	1.12	0.05	11.3	30.0	62.0	5.0	12.7
B	4 Final conc.	100.0	0.66	0.78	84.5	12.03	0.21	100.0	100.0	100.0	100.0	100.0
	2nd Cleaner Tails	10.1	1.82	1.09	54.8	35.5	0.49	28.9	14.2	6.6	31.2	26.9
	1st cleaner tails	13.8	1.33	1.45	64.9	28.5	0.45	28.9	25.8	10.7	34.1	34.1
	Rougher tails	25.6	0.75	1.20	79.3	13.3	0.18	30.3	39.7	24.3	29.5	25.3
	Head (calculated)	50.5	0.15	0.31	96.3	1.19	0.05	11.9	20.3	58.3	5.2	13.7
		100.0	0.64	0.77	83.4	11.53	0.18	100.0	100.0	100.0	100.0	100.0

Table 3 - Flotation parameter data and reagent concentrations

Sample	Test No.	Flotation stage	No. of stages	Cond. Time	Float Time	pH	Pulp Density	Impeller Speed	Collectors		Na ₂ SiO ₃	H ₂ SO ₄	M.I. B.C.
									Duo TDO	Armac T			
				min	min		% solids	r.p.m.	g/t	g/t	g/t	kg/t	g/t
A	1	Rougher	5	25	29	2.0	30	1300	511.5	--	2046.0	14.88	180
		Cleaner	2	10	6	2.0	30	1300	470.6	--	818.4	8.97	36
A	2	Rougher	5	25	21	2.0	30	1300	--	518.5	2074.5	9.13	14.9
		Cleaner	2	10	9	2.0	30	1300	--	--	---	10.64	--
B	1	Rougher	4	24	20	2.0	30	1300	418.8	--	1610.4	13.36	145.0
		Cleaner	2	12	6	2.0	30	1300	458.9	--	805.2	7.11	58.0
B	2	Rougher	4	20	20	2.0	30	1300	--	416.0	3500.0	13.60	86.4
		Cleaner	2	10	9	2.0	30	1300	--	--	---	1.03	57.6

Table 4 - Brightness determinations

Sample	Procedure	Products	Brightness* %
A	Head	+44 μm	67.5
		-44 +25 μm	51.4
		-25 +6 μm	68.6
		-6 μm	74.1
	Float test #1	Final Conc.	73.4
		Rougher tails	74.4
	Float test #2	Final Conc.	72.6
		Rougher tails	74.6
B	Head	Non-magnetic fraction	73.3
		Non-magnetic fraction	72.5
		Non-magnetic fraction	72.5
		Non-magnetic fraction	72.5
	Float test #1	Final conc.	73.0
		Rougher tails	74.0
	Float test #2	Final conc.	73.1
		Rougher tails	73.9
C	Head	Non-magnetic fraction	73.3
		Non-magnetic fraction	72.4
		Non-magnetic fraction	72.4
		Non-magnetic fraction	72.4

* Blue filter used.

Table 5 - Wet magnetic separation tests of combined flotation concentrates

Sample	Product	Wt %	Analysis % Fe ₂ O ₃	Distribution %
A	Magnetics	16.8	2.23	17.5
	Non-magnetics	83.2	2.12	82.5
	Calculated head	100.0	2.14	100.0
B	Magnetics	9.5	1.97	10.2
	Non-magnetics	90.5	1.82	89.8
	Calculated head	100.0	1.83	100.0